CHIEF OF ENGINEERS ENVIRONMENTAL ADVISORY BOARD
U.S. ARMY CORPS OF ENGINEERS (CECW-P)
441 G Street NW
WASHINGTON, D.C. 20314-1000

24 April 2014

LTG Thomas P. Bostick,
Commanding
Headquarters, US Army Corps of Engineers
411 G Street NW
Washington, DC 20314-1000

RE: Environmental Flows

Dear LTG Bostick,

The Environmental Advisory Board (EAB) recommends that the Corps of Engineers initiate **environmental flows** from as many of its dams as possible. Environmental flows (E-flows) are releases from dams and their reservoirs to create downstream river flows that create the conditions needed to sustain fresh water ecosystems. We recommend that the Corps take the following specific actions. The attached report provides extended explanations.

1. Include in Command School for new District Commanders a short segment on the general issue of aquatic ecosystem restoration.

2. Direct District commanders to include as part of each 5-year review of their Water Operations Manuals an assessment of the opportunities for E-flows, and to report to Division commanders the most likely candidates for successful introduction of E-flows. The USACE Engineer Research and Development Center at Vicksburg, Mississippi, along with the USACE Hydrologic Engineering Center at Davis, California, can create a description of general E-flow alternatives, outline the process for establishing them for each dam or river, assess the likely downstream effects, and summarize Corps experiences in a short guidebook.

3. Expand the Sustainable Rivers Project by increasing the number of Corps projects and rivers to 20 by the year 2020.

These recommendations specifically address the Environmental Operating Principles reissued by LTG Bostick in 2012 by (1) fostering sustainability as a way of life in the Corps, (2) proactively considering environmental consequences of Corps activities, (3) creating mutually supportive economic and environmental solutions, (4) meeting Corps responsibility for the agencies operations, (5) considering the environment in Corps systems approach to management, (6) leveraging scientific knowledge, and (7) operating in an open and transparent fashion.

This letter is a follow-up to the EAB's recent visits to Omaha, Nebraska on the Missouri River, Augusta, Georgia on the Savannah River, and Phoenix, Arizona near the Bill Williams River. The Board explored dam operations and successful downstream river restoration by the Corps of Engineers in each of these cases. These visits, along with related experiences of Board members in other locations such as the Green River, Kentucky, have led us to conclude that Corps of

Engineers' dams offer unique opportunities for aquatic ecosystem restoration downstream from Corps dams through environmental flows produced by modified dam operations. Experience shows the Board that commonly such modifications can be undertaken without infringing on authorized uses and can be established coincidentally with normal five-year reviews of water operations plans.

Most Corps dams are large enough to completely alter the downstream hydrologic regime of their rivers. In order to provide social and economic benefits, Corps dams have been designed and operated to change natural river flows by reducing peak discharges to suppress floods, modify flows to adjust reservoir storage, introduce large daily fluctuations to generate electrical power, and maintain long periods of flows without significant fluctuations to support navigation.

Installation and operation of large Corps dams with their accompanying changes in river hydrology have resulted in unforeseen damaging effects on downstream ecosystems. As an example, the substantial reduction in annual peak flows has suppressed many floods, but has also hydrologically disconnected floodplains from their rivers, resulting in large losses of active floodplain areas. Constant increases and decreases of dam releases to generate hydropower produces accelerated bank erosion, and abrupt changes in releases may stress wildlife populations by compromising their nesting, nurturing, feeding, and resting areas.

The same dams that cause negative effects on ecosystems downstream can often be used to improve downstream conditions by making minor changes in operating rules within the limits of existing Water Operations Manuals. The general practice in the USACE is to review these manuals and to update them on a once-every-five-years basis. As each review comes due in this cycle, consideration of the creation of E-flows can be considered as part of normal procedures.

Two examples of E-flows are artificial floods and graduated ramping rates. Artificial floods are flows smaller than pre-dam magnitudes but larger than post-dam flows, large enough to restore active channel habitats and hydrologically reconnect small parts of the flood plain to the river while avoiding downstream economic damages. Graduated ramping rates replace abrupt changes in releases that result in rapid river-level changes with gradual adjustments that more closely mimic natural changes in discharge, allowing ecosystems to function more naturally.

The expansion of the Sustainable Rivers Project to 20 rivers by 2020 will insure that those Corps dams where E-flows can be easily created receive priority, and that their lessons learned and environmental benefits can be obtained as soon as possible.

Sincerely,

Wm L. Graf

William L. Graf
Chair

Encl

CC: Mr. John C. Furry

Report on Environmental Flows

by

Chief of Engineers Environmental Advisory Board

Background

This report focuses on environmental flows from Corps of Engineers' dams. Environmental flows (E-flows) are releases from dams that mimic natural flows as closely as possible to support sustainable aquatic and riparian ecosystems downstream. This report is a follow-up to the Environmental Advisory Board's (EAB) recent visits to Omaha, Nebraska on the Missouri River, Augusta, Georgia on the Savannah River, and Phoenix, Arizona near the Bill Williams River. The Board explored dam operations and downstream river restoration by the Corps of Engineers in each of these cases. These visits along with related experiences of Board members in other locations such as the Green River, Kentucky have led us to conclude that Corps of Engineers' dams offer unique opportunities for river restoration downstream from Corps dams through environmental flows produced by modified dam operations. Experience shows the Board that such modifications can be undertaken without infringing on authorized uses, and the inexpensive planning required for the establishment of environmental flows may temporarily substitute for more extensive and expensive planning for dam operations. After identifying the connection between environmental flows and the Corps' Environmental Operating Principles, we outline downstream ecosystem damage resulting from operations of Corps dams, and describe corrective measures that are available with existing infrastructure. We then explore how E-flows fit administratively within present USACE procedures, and offer as a successful examples the USACE management of the Savannah River and more generally the Corps' limited Sustainable Rivers Project. We conclude with specific recommendations for actions to improve dam operations and better provide for sustainable downstream ecosystems.

Environmental Flows and the Corps' Environmental Operating Principles

The Corps of Engineers' Environmental Operating Principles provide primary policy support for adding environmental flows to the management of dams and their reservoirs. The USACE operates 694 dams in the United States, but only a limited number of them employ environmental flows to help achieve the Corps' operating principles. Adding environmental flow strategies to dam operations can generally be accomplished within existing Water Control Plans and within the scope of existing Water Control Plans, so that they are minimally disruptive to established operational objectives.

(1) E-flows foster sustainable perspectives on dam and reservoir operations and within a watershed context and attention to floodplain systems downstream.

(2) E-flows represent a proactive response to negative downstream consequences associated with Corps of Engineers' facilities.

(3) E-flows are compatible with a symbiotic relationship between economic and ecosystem resources.

(4) E-flows operate within established parameters and within established authorized uses of dams and their reservoirs, and they foster improved environmental health (including for endangered and threatened species) so they support Corps legal responsibilities.

(5) E-flows represent a systems approach and are supportive of risk management.

(6) E-flows leverage the latest research into hydrology, geomorphology, and ecology.

(7) E-flows can be defined in open, transparent processes that protect the interests of all interested parties.

Establishing environmental flows is similarly consistent with the Corps' *Engineering Solutions for a Sustainable and Secure Future*, and with the Department of the Army' Civil Works Strategic Plan 2011-2015, *Sustainable Solutions to America's Water Resources Needs.*

River Flow Changes Resulting from Operation of Corps Dams

The U.S. Army Corps of Engineers owns 694 dams in the United States with the primary objective of controlling river flows for economic benefits to the nation. Flood suppression, generation of hydropower, navigation, control of water supply, and provision of flat-water recreation have commonly been the purposes of these structures. In order to provide these and other benefits, Corps dams have been designed and operated to change natural river flows by reducing peak discharges to suppress floods, increasing the daily variability of flows to adjust reservoir storage, reducing the range of flow volumes as a result of the limiting design of the dams' outlet works, and changing the duration of both high and low flows for water delivery. The dams also change flows by releasing highest and lowest discharges at times of the year that are different from the original natural flows to meet societal demands rather than ecosystem demands. Corps dams equipped with hydropower generation capabilities release highly variable flows on an hourly basis to generate power during peak hourly demand periods, with rapid ramping rates (the rates of change between low and high flows). High levels for reservoir waters also serve the needs of recreational boaters and the owners of private property on the shorelines of reservoirs. Most Corps dams are large enough to completely alter the downstream hydrologic regime of their rivers.

In addition to these downstream hydrologic effects, large Corps dams with large reservoirs trap almost all the sediment flowing into them, so that downstream reaches experience large deficits of sediment in their geomorphic processes. Although some of these problems may be ameliorated by sediment by-pass projects, for most Corps structures these efforts are probably decades away even for planning, so we do not discuss them further in this report.

Ecosystem Damages Resulting from Flow Changes from Corps Dams

Installation and operation of large Corps dams with their accompanying changes in river hydrology have resulted in unforeseen negative effects on ecosystems and populations of species listed under the Endangered Species Act. The substantial reduction in annual peak flows has suppressed many floods, hydrologically disconnected floodplains from their rivers, and damaged aquatic and riparian habitat. River managers therefore lose the benefits and ecosystem services associated with these resources. These abandoned floodplains cannot function as nurseries for fish, habitat for native birds, filtering areas for contaminants, or as storage areas for tributary contributions of sediment. Riparian forests along impounded rivers have lost their natural composition, and invasive species have replaced the original forest. The dam-induced declines in low flows have depleted channel flows so that they cannot support native fishes.

The reduction in the annual range of flows causes fundamental geomorphic and ecologic changes downstream from large Corps dams. The pre-dam flow regimes with their wide variation in flows nurtured a highly complex set of ecosystem patches, some related to the highest flows and some to the lowest, with several patches or surfaces related to various intermediate flows. The more consistent post-dam flows produce highly simplified arrays of habitats tuned to only a limited number of discharge magnitudes. Dam releases that are relatively unchanging are erosive for downstream channel beds and banks that are now starved for replacement sediment now stored in upstream reservoirs. Altered ramping rates contribute to this erosion, and interfere with reproduction of riparian birds and fishes, ecological functions that are also damaged by altered dates for high and low flows.

Restoration of Ecosystem Health by Dam Operations and Environmental Flows

Traditional dam operations cause deleterious effects on downstream ecosystem health, but the same dams can be used to improve downstream conditions by revising operating rules to produce environmental flows that restore natural and social values damaged by existing operating rules. An example of such environmental flows is an artificial flood. Although it is highly unlikely that decision makers would chose to return to floods of pre-dam magnitudes, it may be possible to operate a given dam to generate a smaller flood that is large enough to reconnect some parts of the landscape to the channel, but small enough to avoid downstream flood damages. This approach improves aquatic habitats in channels and riparian habitats on channel margins and floodplains by restoring some of their pre-dam functionality.

Other adjustments in dam releases for environmental flows restore some lost low flows during wetter climatic periods when water is more abundant in reservoirs. Waters passed through the reservoir and dam during periods of high inflows can be released gradually rather than quickly to enhance groundwater recharge. When releases are changed according to previously established release rules, the ramping rates can be administered to be more similar to pre-dam rates rather than instantaneous changes. Releases can be designed to provide variable flows that are more like pre-dam flows rather than releases that are constant at artificially stable magnitudes. Some high or low flows can be more carefully timed to support wildlife reproduction. The Board is familiar with successful environmental flows include those on the Green River, Kentucky, downstream from the Corps' Green River Dam. Artificial floods downstream from the Corps'

Cochiti Dam on the Rio Grande, New Mexico, have stimulated reproduction of native fishes in the river.

In those cases where sediment-starved stream segments downstream from dams require sediment for shallow water habitat and sand bar habitat, some material can be dredged from deeper parts of the channel or from the floodplain and be rearranged to simulate the useful habitat morphology. Examples of these features include reaches below the Corps' Gavins Point Dam, a Corps structure on the Missouri River.

Establishing E-flows within Existing USACE Administrative Procedures

Sources of Information

In order to understand how water control policies for USACE dams work, and how E-flows are included in operating rules for dams, the EAB explored USACE policies and consulted with Mr. Jerry Webb, the Leader of the USACE Hydrology, Hydraulics, and Coastal Practice. His 39 years of experience in operations of Corps dams was particularly helpful in our assessment. We also explored the specific example of Thurmond Dam, a USACE structure on the Savannah River that is presently undergoing the design and implementation of E-flows. In the following subsections we assess the present situation regarding E-flows at USACE facilities, define the process for establishing E-flows, and briefly outline the Savannah River example.

Present Status of E-flows at USACE Facilities

At the present time, a few USACE dams have formal rules governing their water release schedules that create E-flows. Managers of the Green River Dam on the Green River, Kentucky have engaged in development of E-flows for a decade and half, and extensive efforts at installing E-flows have been undertaken at such diverse Corps structures as Roanoke Dam on the Roanoke River (Virginia and North Carolina), Alamo Dam on the Bill Williams River (Arizona), and several dams in the Willamette River Basin (Oregon). USACE managers are presently working to create E-flow rules on the Savannah River (Georgia and South Carolina). Interest in creating E-flow rules is especially high in the Great Lakes and Ohio River Division, including in the Pittsburg District where managers have recently received funding to begin work on E-flows on the Allegheny River (Pennsylvania). The Norfolk District has also expressed interest in basin-wide E-flows. Although there is no accounting of which USACE projects and dams across the nation are employing E-flows, the number of adopters is a limited fraction of the more than 700 USACE dams, leaving much room for improvement.

Experience thus far in installing E-flow guidance in water operations manuals of Corps dams has produced the following generalizations.

- Only a relative few of all the possible candidate USACE dams for E-flows have adopted them.
- Many Corps dams are good candidates for the adoption of E-flows, though the exact number is not known. There are many "low hanging fruit", dams where establishing E-flows would be easy and without disrupting present operational objectives.

- The active involvement and commitment of the District Commander is the primary determining, positive factor in those cases where E-flows have been established.
- Many E-flows can be included in water operations manuals without affecting previously established authorized purposes and without impacting water storage allocations.
- The cost of installing E-flows in USACE water operations manuals is real, but relatively small, usually ranging in the few hundreds of thousands of dollars per dam or project.
- There is a specific, well-known process in USACE guidance and policy for establishing changes such as E-flows in water operations manuals (this process is outlined below).
- E-flows provide substantial increased benefits from existing Corps structures with small investment of operations and maintenance funding.
- The Sustainable Rivers Project assists the establishment of E-flows by demonstrating their effectiveness and providing examples of the development of partnerships for this purpose.

Process for Establishing E-flows at USACE Facilities

The institution of E-flows from USACE dams entails the modification of the water operations manual for the dam (and by extension, its reservoir). This manual contains specific instructions to dam operators for their release of water from the reservoir and the creation of downstream flows in the river below the dam. The manual provides different instructions for different hydro-climatic situations, such as a long-term drought with accompanying low flows, or a particularly wet period when flows are much higher. The manual also specifies how flows are changed, or ramped, up or down in response to changing conditions, generation of power, provision of water for navigation, or creation of flows for other purposes such as environmental conditions in downstream channels or on flood plains.

In considering the change in water operations manuals, there are three types of increasingly complicated adjustment: deviations from present operations, changes in requirements, and changes in authorized purposes. *Deviations* are adjustments in release rules that can be established temporarily for a maximum of three years upon approval by the MSC Commander. E-flows can be approved as deviations, and within a three-year period there is sufficient time to experiment with various forms of E-flows, changing them based on experience in a form of adaptive management.

Changes in requirements can establish E-flows permanently in water operations manuals. For this step, a restudy of releases requires Division approval and the investment of modest amounts of operations and maintenance funding. These costs, up to a maximum of a few hundred thousand dollars, are usually shared among the USACE and its local partners. Authority from the Division level is usually not an impediment, so the process is funding limited at this point.

Changes in authorized purposes require extensive and expensive reallocation studies that aim to redefine the purposes for the project and its dam(s). The final approval authority is the U.S. Congress. The establishment of E-flows does NOT require this level of substantial changes in rules for the water operations manuals.

Because the installment of e-flow rules requires only deviations and changes in requirements, the highest level of approval is the Division. Generally, if changes in operation do not have a significant impact on authorized purposes, changes in water operations manuals require only Division approval. A key decision is when to pursue the issue of E-flows for a given dam. The Leader of the Hydrology, Hydraulics, and Coastal Practice of the USACE reports that it is a general objective that water operations manuals be reviewed once every 5 years, though this frequency is sometimes longer because of funding issues. He states (and the EAB agrees) that the best time to consider establishment of e-flows at each dam is to consider the possibility as part of the regular 5-year update of the manual. If Corps leadership directs that consideration of E-flows be a regular part of the 5-year update of water operations manuals, consideration of the flows can become standard procedure and not impose undue burdens on District or Division personnel.

Savannah River Example

Recent developments in the management of Thurmond Dam, a structure on the Savannah River, Georgia and South Carolina, show how E-flows can be established. The river was included in the original list of rivers in the Sustainable Rivers Project, a joint USACE and Nature Conservancy effort to bring E-flows more broadly into Corps river management. Beginning in 2002 the Corps and their partner, The Nature Conservancy, designed a process to guide the identification of the exact parameters of E-flows for the downstream from Thurmond Dam, and initiated environmental flows for the system. The process was so successful that it is now known as "the Savannah Process", and the effectiveness of E-flows, including pulse flows to simulate in- channel flooding and carefully adjusted ramping rates, is broadly recognized.

The E-flows for the Savannah River vary according to hydro-climatic conditions, so that different flow prescriptions are used for those years that are relatively moist offer different opportunities than those years that are in drought conditions. Recognizing that drought years are particularly difficult to manage, and that after about 2009 the basin has been in a long-term drought condition, the USACE along with Georgia, South Carolina, and The Nature Conservancy agreed to create a Drought Management Plan for the river with Thurmond Dam as a key management component. A cost-share agreement among the four partners was signed in summer 2013 for a total of about $500,000, and work on the drought plan will soon begin. The creation of new E-flow prescriptions specifically for drought periods will be part of the plan.

The Savannah River is an informative case example for establishing E-flows at other Corps dams. The decision and planning process was transparent, involving all interested parties in public meetings. The four major partners are sharing in the financial costs. E-flows were established, and then evaluated and modified based on monitoring data in an adaptive management framework. The creation of new parameters for E-flows was a task that was piggy-backed onto the creation of a drought management plan. District commanders were receptive and supportive of the concepts associated with E-flows as an example of the application of the Corps' Environmental Operating Principles. The efforts on the Savannah River were aided and stimulated by including the river in the Sustainable Rivers Project.

Sustainable Rivers Project as an Example Policy Instrument for Restoration

The Sustainable Rivers Project that aided the implementation of E-flows on the Savannah River offers an existing management program for the development and implementation of E-flows, although this opportunity has yet to be fully leveraged. A December 14, 2000 memorandum of understanding (termed the National Memo) between the USACE and The Nature Conservancy launched the Sustainable Rivers Project (SRP), and a November 15, 2011 addendum between the same two parties solidified the agreement and elaborated on the Great Rivers Partnership. The initial agreement commits the Corps to "improve riverine ecosystems across the United States by modifying operations of Corps dams", and directs the Corps to communicate the MOU to all Division and District offices. Unfortunately, only a small number of Corps dams generate environmental flows, and knowledge about SRP is poorly disseminated among Corps leaders and dam operators.

The first and arguably the most successful effort in the Sustainable Rivers Project is the Green River, Kentucky project that resulted from a partnership between the Kentucky Chapter of The Nature Conservancy and the Louisville District office of the Corps. Environmental flows managed by an altered water operations manual at Green River Dam has produce economic and social benefits, as well as restoring valuable aquatic habitat downstream. A second success story is the cooperation among the USACE and various state and city interests on the Bill Williams River, Arizona, where the Corps' Alamo Dam had desiccated the channel and floodplain. Artificial floods and modified releases from the dam, conducted in partnership with land owners of the flood plain, have restored aquatic habitat and riparian ecosystems.

In addition to these successes, environmental flows in general and the Sustainable Rivers Project in particular have encountered challenges that have prevented the Corps from achieving the potential wide-spread positive impacts envisioned in the original National MOU of 2000. Two challenges must be addressed soon in order to realize the ecosystem benefits of E-flows and the SRP:

First, the potential for environmental flows and the opportunities for SRP are not well known or understood by many Corps officials, particularly at the District and Division levels. Turnover of personnel has resulted in a loss of institutional memory concerning SRP and environmental flows. Many decision makers and managers mistakenly believe that water operations manuals cannot be changed to accommodate such flows without violating authorized operations. In its field visits, the EAB has noted wide variation from one district to another in knowledge about the Corps' restoration mission and Environmental Operating Principles, general Corps policy that underlies the SRP and E-flows.

Second, the number of rivers and Corps dams included in SRP is too limited. Although the project was launched in 2000, it still includes only 8 rivers, and many of those have yet to achieve their goals of modified flows. The EAB finds that even though SRP is more than a dozen years old, its established successes are limited. The Board has observed that the SRP budget is too small to accomplish the project mission, even though that mission directly addresses the current interests of the Corps to improve reservoir management, floodplain

functionality downstream from Corps dams, integration of projects into a more systems/watersheds oriented approach to planning and management.

Recommended Actions

To address river restoration downstream from Corps large dams, the EAB recommends that the Corps take the following actions.

1. Include in Command School for new District Commanders a short segment on the general issue of aquatic ecosystem restoration. This method of reaching command personnel at the district and division levels should emphasize the Corps' Environmental Operating Principles, the role of dam operations in accomplishing some restoration, and the SRP as a guide for such efforts. The EAB could be charged with creating and presenting a short segment of Command School devoted to aquatic ecosystem restoration, using E-flows as an example.

2. Direct District commanders to include as part of each 5-year review of their Water Operations Manuals an assessment of the opportunities for E-flows, and to report to Division commanders the most likely candidates for successful introduction of E-flows. The USACE Engineer Research and Development Center at Vicksburg, Mississippi, and the Hydrologic Engineering Center at Davis, California, can create a description of general E-flow alternatives, outline the process for establishing them for each dam or river, and summarize Corps experiences in a short guidebook for dam managers. By including the evaluation of potential E-flows in each regular 5-year review of operations rules, the initiation of E-flows can become an unobtrusive part of an ongoing process. Because the reviews are repetitive, they can take into account changing environmental and economic conditions. It is unlikely that all Corps dams are equally good candidates for generation of E-flows, in part because all dams have not created the same types of downstream damages. Further, individual dams have physical characteristics such as intake and outlet works that limit their ability to create some types of releases. A systematic description of E-flow alternatives must be provided to operators so that they may determine the applicability of alternatives to individual situations. Some USACE dams already employ environmental flows, and a summary of their experiences can help expand the applications of this concept. The Corps already has considerable intellectual resources to in the matter ecosystem-river interactions and downstream hydrologic changes resulting from dam operations in its Vicksburg and Davis centers.

3. Expand the Sustainable Rivers Project by increasing the number of Corps projects and rivers to 20 by the year 2020. Prioritization of the SRP for funding such an expansion from the present 8 rivers to 20 would likely result in expanding the annual support for the SRP from the existing and inadequate $300,000 per year to $2 million per year as soon as possible. The Corps should undertake this effort in conjunction with its existing partner in SRP, The Nature Conservancy. New rivers and their dams to be included represent the "low hanging fruit", those cases where there is existing interest and potential rapid progress in establishing E-flows. Planning to expand the SRP should commence immediately.